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[Claim 1] A controller for a hybrid vehicle in which a power device, which mutually connects an internal combustion engine and an electric rotating machine in a driveable manner, is arranged in such a manner as to be connectable to a drive system of the vehicle, comprising:

a start condition detecting device for detecting a start condition of the internal combustion engine,

an engine rotation detecting device for detecting a rotation speed of the internal combustion engine, and

a control device for controlling a torque and a rotation speed of the electric rotating machine,

wherein,

the control device is configured so as to perform a torque control in a desired rotation range at start of the engine, and perform a rotation speed control in a rotation range other than the desired rotation range.

[Claim 2] The controller for a hybrid vehicle according to claim 1, wherein the control device is configured so as to perform the torque control in a rotation speed range until a desired engine rotation speed is reached after start-up, and perform the rotation speed control thereafter.

[Claim 3] The controller for a hybrid vehicle according to claim 1 or 2, wherein the torque control is performed based on a torque command value generated by adding a rotational vibration suppressing torque determined according to an engine crank angle to a basic torque value determined according to an elapsed time after start-up.

[Claim 4] The controller for a hybrid vehicle according to claim 3, wherein the rotational vibration suppressing torque assumes a value which offsets an engine torque fluctuation portion near a resonance frequency of an engine mount system, and assumes a predetermined minimum value in a frequency range other than near the resonance frequency.

[Claim 5] The controller for a hybrid vehicle according to claim 4, wherein the value which offsets the engine torque portion is set according to an operation state including an engine coolant temperature.

[0013]

[Operation and Effect]

A main factor of vibration generation during engine start-up is a pulsating torque fluctuation caused by a pumping operation of an engine and a periodic friction operation of a valve system. Characteristics of the torque fluctuation and a vibration-generating rotation range can be recognized in advance by an experiment or the like. Therefore, as in each invention according to claims subsequent to claim 1, if a torque control of an electric rotating machine is performed in a predetermined rotation range during engine start-up, generation of vibration at engine start-up can be suppressed by applying torque that offsets torque pulsation in a rotation range in which torque pulsation occur. On the other hand, a rotation speed control is performed in a rotation range other than that of the torque control. Consequently, increase in the rotation speed during start-up of the engine or convergence to a target rotation speed after start-up is achieved promptly, thus achieving favorable driveability at the time of transition from running by the electric motor to that by the internal combustion engine.

[0032]

In the torque control, a basic output torque T_a , a rotational vibration suppressing torque T_b , and a compensation coefficient K_t for T_b (provided that $K_t \leq 1$) are calculated, respectively (Steps 505 to 507). The basic output torque T_a is for securing a basic torque necessary for engine start cranking, and is given, for example, with a characteristic so as to increase with elapse of time after start of the engine start-up as shown in Fig. 6. The rotational vibration suppressing torque T_b is for offsetting pulsating torque fluctuation occurred in an engine main shaft due to the engine pumping operation and the friction resistance of the valve system as described above. A torque characteristic necessary to offset the torque fluctuation is predetermined based on an experiment, and the rotational vibration suppressing torque T_b is given with a characteristic shown in Fig. 7. The compensation coefficient K_t is set as shown by an example in Fig. 8, and is for suppressing a motor driving power to minimum by applying the rotational vibration suppressing torque T_b only in a specific rotation range in which vibration occurs, for example, in the vicinity of a resonance frequency range of an engine mount. A final torque command value S_t is obtained by superimposing on the basic output torque T_a a torque calculated by multiplying the rotational vibration suppressing torque T_b by the compensation coefficient K_t , and a control that outputs the thus obtained command value S_t to drive the motor 1 is repeated (Steps 508 and 509). As a result, unpleasant vibration that occurs in the process of engine start-up

can be reduced effectively.

[0034]

Figs. 9 to 11 indicate results of an experiment according to the aforementioned control. The figures show, according to execution or non-execution of viscosity compensation and pulsation correction, a relationship of a rotation speed and engine vibration (vertical acceleration) when an engine throttle is fully opened to change the rotation speed from 0 to 700 rpm. The viscosity compensation refers to torque correction that mainly considers friction resistance of the valve system or the like, and the pulsation correction refers to torque correction that mainly considers the pumping operation. Fig. 9 shows an effect of the embodiment of the invention in a case in which respective corrections are performed. Fig. 10 shows a case in which the pulsation correction only is performed. Fig. 11 shows a case in which the viscosity compensation only is performed. Comparison of Figs. 9 and 10 reveals that a rotation-speed following performance, with respect to a rotation command value, immediately after start-up is improved by the viscosity compensation. Moreover, it can be recognized from comparison of Figs. 9 and 11 that rotational pulsation and vibration are sufficiently reduced by the pulsation compensation.